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EXPERIMENTAL STUDIES ON ELECTROMIC PROPERTIES OF
HGTE/CDTE AND HG(1-X)CD((U) PRINCETON UNIV NJ DEPT OF
PHYSICS N ONG 18 DEC 87 ARO-23975 3-PH

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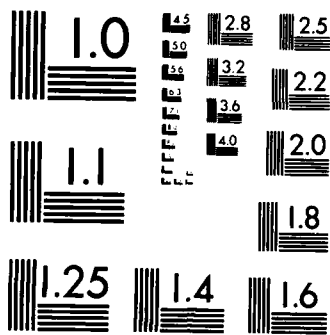
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TITLE

Experimental studies on electronic properties of HgTe/CdTe and
Hg_{1-x}Cd_xTe/CdTe heterostructures and superlattices.

TYPE OF REPORT (TECHNICAL, FINAL, ETC.)

Final

AUTHOR (S)

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DATE

December 10th 1987

U. S. ARMY RESEARCH OFFICE

CONTRACT / GRANT NUMBER

DAAG29-84-K-0032 (at University of Southern California)
DAAL03-86-K-0052 (at Princeton University)

INSTITUTION

University of Southern California (3/1/84 through 9/1/85)
Princeton University (4/2/86 through 9/30/87)

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88 1 82 113

Bc. ADDRESS (City, State, and ZIP Code)

P. O. Box 12211
Research Triangle Park, NC 27709-2211

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Experimental studies on electronic properties of HgTe/CdTe and $\text{Hg}_{1-x}\text{Cd}_x\text{Te}/\text{CdTe}$ hetero-structures and superlattices

12. PERSONAL AUTHOR(S)

Professor Nai-Phuan Ong

13a. TYPE OF REPORT

Final

13b. TIME COVERED

FROM 3/1/84 TO 9/30/87

14. DATE OF REPORT (Year, Month, Day)

1987 December 10th

15. PAGE COUNT

2

16. SUPPLEMENTARY NOTATION

The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

HgTe-CdTe superlattices, heterostructures, quantised Hall effect, weak localisation, spin-orbit time, inelastic time

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

CdTe, AlGaAs, GaAs, InP, Mercury telluride, Aluminum Gallium Arsenide, Gallium Arsenide
In this project the electronic properties of superlattices made of alternating layers of HgTe and CdTe have been studied at low temperatures T (down to 0.5 K) and in high dc magnetic fields (up to 29 T.) There were two motivations for performing these studies. 1) Whereas superlattices made from III-V materials such as AlGaAs-GaAs and InP have been fabricated and shown to support very high mobility electrons in two-dimensional wells, similar studies had not been performed on the II-VI compounds. In 1982 Dr. Jeff Cheung at Rockwell, Thousand Oaks, succeeded in fabricating superlattices of HgTe and CdTe using a novel laser flash evaporation technique. Initial studies by our group (then at University of Southern California) showed that prospects looked good for realizing excellent two-dimensional electronic devices despite the poor mobility ($3,000 \text{ cm}^2/\text{Vs}$) of the early samples. 2) On the practical side, far-infrared (FIR) detectors made from the bulk alloy $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ suffer from inhomogeneity problems which lead to spatial variations of the gap, especially in the 10

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21. ABSTRACT SECURITY CLASSIFICATION

Unclassified

contd. micrometers

- (a) μm range. Following suggestions by McGill and Schulman (that the gap in superlattice HgTe-CdTe can be tuned by changing the periodicity) we also explored the FIR capabilities in the Rockwell samples.

In publication 1 by Boero et al we found that there was an absorption peak of the early superlattice samples centered near 20 cm^{-1} . The absorption peak was detected by the photoconductive response of the superlattice when irradiated with FIR radiation from a molecular gas laser pumped with a CO_2 laser. The dc magnetoresistance was also measured in fields up to 15 T. Weak quantum oscillations were observed in the resistivities ρ_{xx} and ρ_{xy} . In 1985 improvements in Cheung's growth technique resulted in a ten-fold jump of the mobility to $40,000\text{ cm}^2/\text{Vs}$. We immediately saw strong quantum oscillations in ρ_{xx} and ρ_{xy} . At low T and high fields these oscillations were consistent with the integral Quantum Hall Effect (QHE), and is reported as Publications 2 and 3. In contrast to the GaAs systems, however, the oscillations displayed strong beating effects which complicated identification of the quantum numbers (or filling factors) as the field B increased. At the same time we made very extensive studies of the weak localisation effects could be observed in the weak field magnetoresistance in fields under 40 Gauss. By fitting the data to the theory of Hikami et al we extracted quite convincing numbers for the spin-orbit scattering rate and the inelastic scattering rate. We could show that these numbers were consistent with several physical tests. To our knowledge this is the first report of measurements of these numbers in HgTe. This appears in Publication 4. In 1985 the present contract was transferred to Princeton University with the PI. In 1986 an invited talk (Pub. 5) on the QHE and weak localisation work was given at the U.S. Workshop on the Physics and Chemistry of Mercury Cadmium Telluride at Dallas.

Students and post-doctorals supported.

1. Francis J. Boero was partially supported during the last months of his PhD thesis. Earned his PhD in Physics from University of Southern California in 1984.
2. John Moyle was fully supported. Earned his PhD. in Physics from University of Southern California in 1986.
3. Z.Z. Wang was supported partially as a post-doctoral associate at Princeton University.
4. Jefferey Clayhold was partially supported as a graduate student (in pursuit of a PhD) at Princeton University.

Publications:

1. "Far-infrared and High Field Magnetotransport studies on a New Superlattice: HgTe/CdTe." F.J. Boero, N.P. Ong and J.T. Cheung, Solid State Commun. **54**, 35 (1985).
2. "Weak localisation and interaction effects in two-dimensional HgTe films and HgTe/CdTe superlattices." J.M. Moyle, N.P. Ong, J.T. Cheung and J. Bajaj, Annual Rept. Francis Bitter National Magnet Lab. 1984-1985, p. 117.
3. "The Quantum Hall Effect in an electron-hole system: HgTe/CdTe superlattice." J.K. Moyle, N.P. Ong, J.T. Cheung and J. Bajaj, Solid State Commun. to be submitted.
4. "Spin-orbit scattering time and dephasing time of carriers in two-dimensional HgTe-CdTe superlattices and heterojunctions." J.K. Moyle, J.T. Cheung and N.P. Ong, Phys. Rev. B **35**, 5639 (1987).
5. "Quantized Hall effect and weak localisation effects in two-dimensional HgTe-CdTe superlattices." N.P. Ong, John K. Moyle, J. Bajaj, and J.T. Cheung, J. Vac. Sci. Technol. **A5**(5), 3079 (1987).

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